without limitation: color, intensity, density, field strength, and temperature. Discrete samples of such parameters are assembled, eg. in a matrix [d], to describe an image of the media. In the paper by (L. I., Rudin, Osher, S. and Fatemi, E., "Nonlinear total variation based noise removal algorithms," Physica D, 60, (1992), pp. 259–268) a total variation (TV) based approach to reconstruction of noisy, blurred images has been introduced. This approach uses a total variation stabilizing functional, which is essentially L_1 norm of the gradient:

$$s_{TV}(m)=\|\nabla m\|_{L_1}=\int_v|\nabla m|dv. \tag{7}$$

This criterion requires that an image's parameter distribution in some domain V be of bounded variation (for definition and background see (E., Giusti, "Minimal surfaces and functions of bounded variations," Birkhauser (1984)). However, this functional is not differentiable at zero. To avoid this difficulty, Acar and Vogel introduced a modified TV stabilizing functional (R., Acar, and C. R., Vogel, "Analysis of total variation penalty methods," Inverse Problems, 10, (1994), pp. 1217–1229):

$$s_{\beta TV}(m)=\int_v\sqrt{|\nabla \mathrm{m}|^2+e^2}dv. \tag{8}$$

The advantage of this functional is that it doesn't require that the function m is continuous, but just that it is piecewise smooth (C. R., Vogel, and M. E., Oman, "A fast, robust algorithm for total variation based reconstruction of noisy, blurred images," IEEE Transactions on Image Processing, (1997)). The TV norm doesn't penalize discontinuity in the image parameters, so we can remove oscillations while sharp conductivity contrasts will be preserved. At the same time it imposes a limit on the total variation of m and on the combined arc length of the curves along which m is discontinuous.

TV functionals s_{TV}(m) and $s_{\beta TV}$(m), however, tend to decrease bounds of the image parameters variation, as can be seen from (7) and (8), and in this way still try to "smooth" the real image, but this "smoothness" is much weaker than in the case of traditional stabilizers (6) and (5).

In yet another development A. S. Carasso introduced a procedure for digital image restoration based on Tikhonov regularization theory and description of the blurred image d as the end result of a diffusion process applied to the desired ideal image m (A. S., Carasso, "Overcoming Holder Continuity in Ill-Posed Continuation Problems," SIAM Journal on Numerical Analysis, Volume 31, No. 6, December 1994, pp. 1535–1557; C. E., Carasso, U.S. Pat. No. 5,627,918, May 1997). In the framework of Carasso's method the image restoration procedure is equivalent to solving diffusion equation backwards in time using the given degraded image d as data at the final moment of diffusion. The desired ideal image is the corresponding solution of the diffusion equation at the initial time moment. To generate a stable solution, Carasso suggests to use a constraint

$$\|m-B^5m\|=\min,$$

where B^5 is the fractional power of the operator B.

The main limitation of Carasso's approach is that it can be applied only to a specific class of integral blurring operators, which can be described by the diffusion problem solution.

In yet another development (H. Kwan, and J. T., Liang, Digital image sharpening method using SVD block transform, U.S. Pat. No. 4,945,502, Jul. 1990), the authors suggest to use the Singular Value Decomposition technique and a priori known information about the statistical properties of the noise and image texture to suppress the noise in the degraded images.

The foregoing attempts met with varying degrees of success in developing the methods of digital image restoration. However, from the point of view of practical applications, these methods are not entirely satisfactory. Therefore, it is highly desirable to develop a method which can be applied to a wide variety of image restoration problems.

DISCLOSURE OF THE INVENTION

In the method of the present invention, a new approach to digital image enhancement and sharpening is developed based on a new type of constraint on the solution which generates focused and sharp images.

The method of the present invention may be used in industrial applications, including biomedical imaging for human body study, for example, in breast cancer diagnosis, (see S. Webbet et al., "Constrained Deconvolution of SPECT Liver Tomograms by Direct Digital Image Restoration," Medical Physics, Vol. 12 (1985), pp. 53–58; U. Raft et al., "Improvement of Lesion Detection in Scintigraphic Images by SVD Techniques for Resolution Recovery," IEEE Transactions on Medical Imaging, Vol. MI-5(1986), pp. 35–44; B. C. Penney et al., "Constrained Least Squares Restoration of Nuclear Medicine images; Selecting the Coarseness Function," Medical Physics, Vol. 14 (1987), pp. 849–859; B. C. Penney et al., "Relative Importance of the Error Sources in Wiener Restoration of Scintigrams," IEEE Transactions on Medical Imaging, Vol. 9 (1990), pp. 60–70; K. S. Pentlow et al., "Quantitative Imaging Using Positron Emission Tomography with Applications to Radioimmunodiagnosis and Radioimmunot! herapy," Medical Physics, Vol. 18 (1991), pp. 357–366); magnetic resonance imaging (see S. M. Mohapatva et al. "Transfer Function Measurement and Analysis for a Magnetic Resonance Imager," Medical Physics, Vol. 18 (1991), pp. 1141–1144); and computed tomography scanners (see E. L. Nickoloff and R. Riley, "A Simplified Approach for Modulation Transfer Function Determinations in Computed Tomography," Medical Physics, Vol. 12 (1985), pp. 437–442).

The method of the present invention may also find application in night vision systems; imaging through the atmosphere; in observational astronomy (see N. S. Kopeika, "Imaging Through the Atmosphere for Airborne Reconnaissance," Optical Engineering, Vol. 26 (1987), pp. 1146–1154; J. D. Gonglewski and D. G. Voelz, "Laboratory and Field Results in Low Light Post-detection Turbulence Compensation Using Self Referenced Speckle Holography," Digital Image Synthesis and Inverse Optics, Proceedings of the Society of Photo-Optical Instrumentation Engineers, Vol. 1351, A. E. Gmitro, P. S. Idell, and I. J. LaHaie, Eds. (1990), pp. 798–806).

The instant method may also find excellent application in geophysical exploration for generating sharp resolved seismic, electromagnetic and gravity images of underground geological structures, for undersea imaging, in airborne geological and geophysical sensing and remote sensing for imaging from satellites (see M. Bath, "Modern Spectral Analysis with Geophysical Applications," Society of Exploration Geophysicists, (1995), 530 pp.; C. A. Legg, "Remote sensing and geographic information systems," John Wiley & Sons, Chichester, (1994), 157 pp.). Other important image sharpening applications of the present method include high definition television (HDTV) (see N. V. Rao, "Development of a High-Resolution Camera Tube for 2000-Line TV